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Elusive active galactic nuclei

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ABSTRACT

A fraction of active galactic nuclei do not show the classical Seyfert-type signatures in their optical spectra, i.e. they are optically ‘elusive’. X-ray observations are an optimal tool to identify this class of objects. We combine new *Chandra* observations with archival X-ray data in order to obtain a first estimate of the fraction of elusive active galactic nuclei (AGN) in local galaxies and to constrain their nature. Our results suggest that elusive AGN have a local density comparable to or even higher than optically classified Seyfert nuclei. Most elusive AGN are heavily absorbed in the X-rays, with gas column densities exceeding 10^{24} cm^{−2}, suggesting that their peculiar nature is associated with obscuration. It is likely that in elusive AGN the nuclear UV source is completely embedded and the ionizing photons cannot escape, which prevents the formation of a classical narrow-line region. Elusive AGN may contribute significantly to the 30-keV bump of the X-ray background.

Key words: galaxies: active – galaxies: nuclei – galaxies: Seyfert – X-rays: galaxies.

1 INTRODUCTION AND DEFINITION OF ‘ELUSIVE AGN’

There is growing evidence that the classification of galactic nuclei based on their optical spectra alone provides an incomplete and sometimes deceiving description of their true nature. Indeed, some ‘classical’ starburst galaxies show signatures of a hidden active galactic nucleus (AGN) at non-optical wavelengths. The most convincing evidence for obscured AGN hidden in starburst nuclei comes from X-ray observations. The prototype of this class of objects is NGC 4945 which hosts a powerful nuclear starburst, identified through emission in the Br γ and Pa α lines and through its mid-IR spectrum (Marconi et al. 2000; Moorwood et al. 1996). The observations indicate that a starburst superwind has created a large cavity where shocked clouds emit faint LINER-type lines. Studies at optical and near-IR wavelengths reveal no evidence for an AGN in this galaxy. However, X-ray observations unambiguously prove the presence of a powerful and heavily obscured AGN: the 2–10 keV spectrum shows a reflection-dominated component with a prominent Fe line, while the intrinsic transmitted component is observed as a strong, variable excess in the range 10–100 keV (Done, Madejski & Smith 1996; Guainazzi et al. 2000). Similar cases are

NGC 6240 (Vignati et al. 1999), which has an optical spectrum very similar to that of NGC 4945 (i.e. weak LINER-type lines probably associated with the starburst superwind shocks; Lutz, Veilleux & Genzel 1999), and NGC 3690 (Della Ceca et al. 2002) which has an H II type optical spectrum. In all three galaxies, X-ray observations clearly indicate the presence of an obscured active nucleus, yet their optical spectra show no signs of the ‘classical’ Seyfert-type emission lines.

We define ‘optically elusive AGNs,’ or simply ‘elusive AGNs,’ those objects that do not show a Seyfert-like spectrum in the optical, but which host a hard X-ray nuclear source with intrinsic luminosity in the Seyfert range, i.e. $L_{2-10\text{ keV}} > 10^{41}$ erg s^{−1}. Therefore, elusive AGN are generally hosted in nuclei optically classified either as H II or LINER.

We emphasize that a LINER spectrum does not necessarily imply the presence of an AGN with Seyfert-like luminosity. For instance, most low-luminosity nuclei studied by Ho et al. (2001) with classical LINER spectra are intrinsically much weaker than classical Seyferts ($L_{2-10\text{ keV}} \approx 10^{38}$ erg s^{−1}). Alternatively, LINER spectra may originate in starburst-driven shocks (Heckman, Armus & Miley 1990; Lutz et al. 1999) and therefore be totally unrelated with the presence of an AGN. An object with a LINER-like spectrum but $L_{2-10\text{ keV}} > 10^{41}$ erg s^{−1} will be therefore considered as an elusive AGN.

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We have started a programme to search for elusive AGN in starburst galaxies using infrared, radio and X-ray observations. In this paper, we present the results of a small set of *Chandra* observations. In combination with literature X-ray data for other galaxies, we derive a first estimate of the fraction of elusive AGNs in the local Universe and attempt to constrain their nature.

2 THE GALAXY SAMPLE

The parent sample consists of all non-Seyfert galaxies (typically starburst with H II or LINER spectra) which show a high brightness temperature ($T_b > 10^5$ K) in the VLBI observations obtained by Kewley et al. (2000) and Smith, Lonsdale & Lonsdale (1998a). The selection based on the presence of a radio core was made to maximize the chance of finding an elusive AGN. Indeed, most Seyfert nuclei show a compact radio core with brightness temperature higher than 10^5 K. However, brightness temperatures even in excess of 10^7 K can also be achieved by compact radio SNe (Smith et al. 1998b). Therefore, the detection of a radio core alone is not a proof for the presence of an AGN.

Kewley et al. (2000) selected nearby galaxies ($z < 0.025$) from the IRAS catalog with luminosity $L_{\text{IR}} > 10^{9.5} L_{\odot}$ (most of these have $L_{\text{IR}} < 10^{11} L_{\odot}$), and warm infrared colours: $F_{60\mu\text{m}}/F_{100\mu\text{m}} > 0.5$ and $F_{60\mu\text{m}}/F_{25\mu\text{m}} < 8$. The warm colours are expected to favour the selection of galaxies hosting AGN. The Kewley et al. sample contains 61 galaxies, 48 of which were observed with the Parkes Tidbinbilla Interferometer (PTI). PTI detections imply $T_b > 10^5$ K.

Smith et al. (1998a) selected the 40 most luminous galaxies in the IRAS Bright Galaxy Sample ($L_{\text{IR}} > 10^{11.25} L_{\odot}$) and observed with the VLBI the subsample of the 31 galaxies with best VLA compact fluxes. Detections with the VLBI generally identify higher brightness temperatures ($T_b \gg 10^7$ K in several cases).

3 X-RAY IDENTIFICATION OF ELUSIVE AGN

Since, by definition, elusive AGN cannot be identified through the classical diagnostic diagrams involving optical line ratios, we have to rely on X-ray-based classification schemes. We infer the presence of an AGN if one of the following conditions is met.

(i) For Compton-thin AGN: an absorption-corrected X-ray *nuclear* luminosity of $L_{2-10\text{keV}} > 10^{41} \text{ erg s}^{-1}$ and a spectrum that can be described by an absorbed power law with AGN-like slope ($\Gamma \sim 1.7$).

(ii) For Compton-thick AGN: a flat X-ray spectrum (power law with $\Gamma < 1.0$) in the case of cold reflection,¹ and/or an Fe line at 6.4–6.7 keV with equivalent width (EW) in excess of 500 eV,² and/or the direct detection of the AGN emission at $E > 10$ keV (e.g. NGC 4945).

This definition is not as well-defined as the one adopted for the optical identification of Seyfert nuclei, and is subject to some ambiguities, as discussed below.

3.1 New *Chandra* observations

We have used *Chandra*/ACIS-S to search for elusive AGN in four galaxies of our parent sample, namely UGC 2369, NGC 2623, NGC

Table 1. New *Chandra* observations of galaxies with radio cores and optically not classified as Seyfert.

Name	T_{int}^a	cts ^b	F_X^c	N_{H}^d	Γ	kT
U2369	10	112	4.9	3^{+1}_{-1}	$1.3^{+0.9}_{-0.7}$	$0.8^{+0.1}_{-0.1}$
N2623	20	129	13.0	9^{+4}_{-2}	$-0.3^{+0.15}_{-0.16}$	$0.6^{+0.2}_{-0.1}$
N2993	50	650	8.7	< 1.2	$1.37^{+0.20}_{-0.20}$	–
N4418	20	25	1.5	0.2^e	$0.76^{+0.61}_{-0.62}$	–
N4691	10	24	1.4	0.2^e	$1.91^{+0.63}_{-0.64}$	–

^aIntegration time in ks.

^bBackground subtracted counts.

^c0.3–8 keV observed flux in $10^{-14} \text{ erg s}^{-1} \text{ cm}^{-2}$.

^dAbsorbing column density in units of 10^{21} cm^{-2} .

^eFrozen to the Galactic value.

4418, and NGC 4691. In addition, we include ACIS-S observations of NGC 2993 which were serendipitously obtained during observations of the companion NGC 2992 (Colbert et al., in preparation). The data were reduced using CIAO v.2.3, following standard procedures. Table 1 gives a short observation log. In all cases, the nuclear X-ray source discussed here lies within $1''$ of the position of the radio core or the near-IR peak, and thus can confidently be identified with the galaxy nucleus. The X-ray fluxes from the nuclear sources are too weak to perform a detailed spectral analysis. For our analyses we used the C-statistics which is more appropriate in the case of low signal-to-noise data (Cash 1979). The weakest sources were fit with a simple power-law using a column density N_{H} fixed to the Galactic value. For the brighter sources, the fit was improved by including a thermal component and/or by varying the value of intrinsic N_{H} . A summary of the best fit for each source is given in Table 1.

NGC 2623 is the only source which unambiguously meets the above criteria for the presence of an obscured AGN, since its very flat hard X-ray spectrum can only be explained by the presence of a Compton-thick, cold reflection dominated AGN. Our data constrain the EW of the Fe line to an upper limit of 1 keV. This value is somewhat lower than in typical Compton-thick AGN (Fig. 1), but not unusual among other elusive AGN such as NGC 4945 (Bassani et al. 1999) or NGC 3690 (Della Ceca et al. 2002). An absorbed power law with Γ frozen to 1.9 gives a much worse fit.

NGC 4418 also shows evidence for a flat spectrum emission component which may imply the presence of a Compton-thick AGN, but the limited photon statistics make this identification somewhat tentative. We note, however, that infrared observations also suggest the presence of a heavily obscured AGN in this galaxy (Spoon et al. 2001; Dudley & Wynn-Williams 1997). Also in this case, an absorbed power law with Γ frozen to 1.9 gives a significantly worse fit.

3.2 X-ray data from the literature

We have collected additional hard X-ray data available in the literature for other galaxies of our parent sample. The objects for which hard X-ray data are available are listed in Table 2, where we also report the optical classification of the nuclei: H II and LINER are self-explanatory, while ‘N4945’ indicates a spectrum similar to that of NGC 4945, i.e. weak LINER-type lines around H α , while H β and [O III] λ 5007 are undetected. In principle, the absence of H β and [O III] λ 5007 does not allow one to distinguish between Sy2 and LINER. However, in NGC 4945 Moorwood et al. (1996) showed

¹ This limiting value for $\Gamma < 1.0$ was chosen because most cold-reflection-dominated, Compton-thick sources are in this range (Bassani et al. 1999; Maiolino, Salvati & Bassani 1998) and also to discard ULXs, which have $\Gamma > 1$ (Foschini et al. 2002).

² This is the minimum value for a Compton-thick AGN found in Bassani et al. (1999)

Table 2. Hard X-ray properties of galaxies with radio cores and optically not classified as Seyfert.

Name	Opt. ^a	X ^b	lg L_X ^c	lg (N_H) ^d
11 < lg (L_{IR}/L_\odot) < 12				
UGC 2369	H II ^{1,8}	— ⁱ		
NGC 2623	N4945 ^{1,8}	AGN ⁱ	≈42.9 ^e	>24
UGC 5101	LINER ^{2,8,9}	AGN ⁱⁱ	≈43.3 ^e	>24
NGC 3690	H II ^{1,8}	AGN ⁱⁱⁱ	42.7	24.4
I1525+36	LINER ^{2,8}	— ^{iv}		
NGC 6240	LINER ^{1,7}	AGN ^v	44.2	24.3
lg (L_{IR}/L_\odot) < 11				
NGC 253	H II ^{7,12}	AGN(?) ^{vi}	39 (42 ^e)	23.3 (>24)
NGC 1672	H II ^{3,7,10}	— ^{vii}		
NGC 1808	H II ^{3,7,11}	AGN ^{viii}	41.3	22.5
NGC 2993	H II ^{4,7}	— ⁱ		
NGC 4418	N4945 ^{2,13}	AGN(?) ⁱ	(41.2 ^e)	(>24)
NGC 4691	H II ^{7,5}	— ⁱ		
NGC 4945	N4945 ⁶	AGN ^{ix}	42.8	24.6

^aOptical classification (see text); references and notes: ¹Wu et al. (1998); ²Baan, Salzer & Lewinter (1998); ³Veron-Cetty & Veron (1986); ⁴Usui, Saitō (2001); ⁵García-Barreto et al. (1999); ⁶Moorwood et al. (1996); ⁷Kewley et al. (2000); ⁸Smith et al. (1998a); ⁹the integrated line ratios of UGC5101 are LINER-like (^{2,8}), but Gonçalves, Véron-Cetty & Véron (1999) claim the detection of Sy-like optical signatures after a multi-component fitting analysis; ¹⁰the integrated line ratios of NGC 1672 are H II-like (⁷), but Veron, Veron & Zuiderwijk (1981) claim the detection of Sy-like optical signatures after a multi-component fitting analysis; ¹¹Phillips (1993) dismissed previous claims for the presence of Sy-like signatures in the optical spectrum; ¹²Moran, Halpern & Helfand (1996); ¹³Lehnert & Heckman (1995).

^bX-ray evidence for an AGN is marked on this column. References for the X-ray observations are: ⁱthis work; ⁱⁱPtak et al. (2003); ⁱⁱⁱDella Ceca et al. (2002); ^{iv}Franceschini et al. (2003); ^vVignati et al. (1999); ^{vi}Weaver et al. (2002); ^{vii}de Naray et al. (2000); ^{viii}Bassani et al. (1999); ^{ix}Guainazzi et al. (2000).

^cLog of the absorption corrected 2–10 keV luminosity (erg s^{−1}).

^dLog of absorbing N_H in units of cm^{−2}.

^eCompton-thick objects for which the intrinsic X-ray luminosity is inferred by assuming a 1 per cent reflection efficiency (with the exception of NGC 253, see text).

that the overall spectral properties are inconsistent with Sy2. For the other two objects with N4945-like spectra (namely NGC 2623 and NGC 4418) the spectral coverage and quality of the optical spectra do not allow to reach similarly firm conclusions. However, at least in the case of NGC 4418, for which Lehnert & Heckman (1995) present data with higher spectral resolution, the width of the lines is more consistent with LINERs than Seyferts. In the third column of Table 2, we mark those objects that have X-ray spectra with evidence for an obscured AGN. In these cases, we provide the absorption-corrected 2–10 keV luminosity and the column density of absorbing gas N_H . For Compton-thick AGN where only the reflection component is observed, we estimate the intrinsic luminosity by assuming a reflection efficiency of 1 per cent (with the exception of NGC 253 discussed below).

Some additional explanation is required for NGC 253 and NGC 1808. NGC 253 was found to host a low-luminosity AGN with observed $L_{2-10\text{keV}} = 10^{39}$ erg s^{−1} which is obscured by $N_H \sim 2 \times 10^{23}$ cm^{−2} (Weaver et al. 2002). However, as discussed by Weaver et al., the detection of a broad radio recombination line by Mohan, Anantharamaiah & Goss (2002) strongly suggests that the nucleus

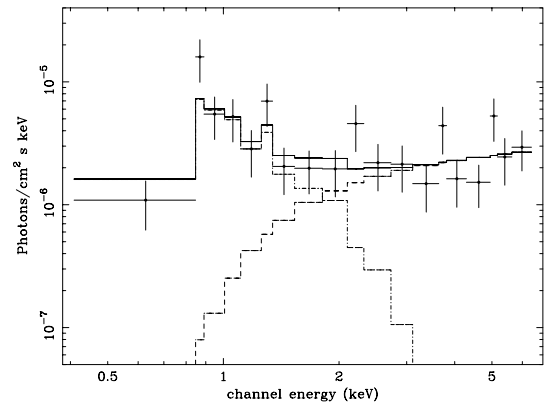
is absorbed by Compton-thick material and that the intrinsic X-ray luminosity is ~ 1000 times higher. NGC1808, on the other hand, appears to be variable: in 1990, Polletta et al. (1996) found evidence for a mildly absorbed AGN with $L_{2-10\text{keV}} = 2 \times 10^{41}$ erg s^{−1}, but observations at later epochs (Bassani et al. 1999) demonstrated that the nuclear source was fainter by a factor of a few. It is possible that the elusive nature of this AGN is caused by fading rather than obscuration.

4 THE FRACTION OF ELUSIVE AGN

Despite the limited statistics, we can make a first attempt at estimating the fraction of elusive AGN in the local universe. As discussed by various authors (e.g. Veilleux, Kim & Sanders 1999; Sanders & Mirabel 1996), the fraction of AGN in galaxies increases with increasing infrared luminosity. Similarly to these studies, we divide our sample by infrared luminosity and, more specifically, into two bins: $10^{9.5} < L_{IR}/L_\odot < 10^{11}$ and $10^{11} < L_{IR}/L_\odot < 10^{12}$. For consistency with Veilleux et al., we adopt $H_0 = 75$ km s^{−1} Mpc^{−1}.

The $10^{9.5} < L_{IR}/L_\odot < 10^{11}$ range. In this luminosity range, the evidence for elusive AGN is more ambiguous than in the higher luminosity bin. NGC 4945 falls into this luminosity range: it is a clear case of an elusive AGN and is listed in Table 2 as a prototype for this class of objects. However, it is not included in our parent sample because its infrared colours are cooler than the selection threshold of Kewley et al. (2000). Therefore, NGC 4945 will not be counted in the statistics used to derive the local fraction of elusive AGN.

About 48 per cent of the local galaxies with $10^{9.5} < L_{IR}/L_\odot < 10^{11}$ (from the IRAS Bright Galaxy Survey, Sanders et al. 1995) have infrared colours matching the selection criterion used by Kewley et al. (2000). We conservatively assume that elusive AGN are only hosted in galaxies matching the Kewley et al. IR colour criteria. In their sample, 42 per cent of the galaxies not classified as Seyfert host a radio core. Of these, 6 galaxies have been observed in the hard X-rays (Table 2) and 3 of them appear to host an elusive AGN, though 2 of these are dubious. Therefore, a rough estimate of the fraction of elusive AGN in this luminosity range is $48 \times 42 \times 3/6 \approx 10$ per cent; if we exclude the two dubious cases the fraction estimate drops to ~ 3 per cent. We summarize this result in Fig. 2, where we include the fraction of local galaxies with optically identified AGN derived by Maiolino & Rieke (1995), i.e. 2 per cent for

**Figure 1.** Unfolded *Chandra* spectrum of the nucleus of NGC 2623 fitted with a power law ($\Gamma = -0.3$) and a thermal component ($kT = 0.6$ keV).

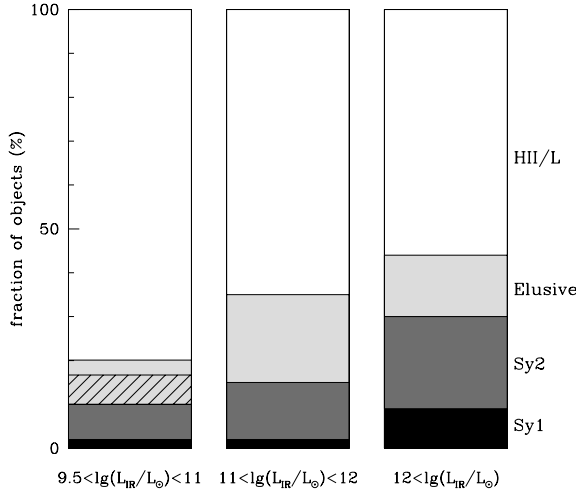


Figure 2. Estimated fraction of Seyfert and elusive AGN in different infrared luminosity ranges. The hatched region in the lowest luminosity bin indicates the fraction of elusive AGN inferred from ambiguous cases.

Sy1 and 8 per cent for Sy2.³ While this calculation is affected by small-number statistics and the uncertain observational evidence for elusive AGNs in this luminosity bin, we argue below that it should at least represent a lower limit to the actual fraction of elusive AGN in the local Universe.

The $10^{11} < L_{\text{IR}}/L_{\odot} < 10^{12}$ range. The clearest cases for elusive AGN can be found in this luminosity range. Four out of the six objects observed in hard X-rays clearly host a heavily obscured AGN.

All galaxies in this luminosity range are from the Smith et al. (1998a) sample, with the exception of NGC 6240 and NGC1614 which are in Kewley et al. (2000). There are 34 galaxies in the parent sample not classified as Seyfert, 25 of which were observed with VLBI. We conservatively assume that galaxies not observed or not detected with VLBI do not contain elusive AGN. 16 of the galaxies observed with VLBI were found to have $T_b > 10^5$ K (about half of them have $T_b \gg 10^7$ K). Six of the galaxies with $T_b > 10^5$ K core were observed in the hard X-rays (Table 2) and 4 were found to host an obscured AGN. Thus, the fraction of X-ray-detected elusive AGN in this luminosity range can be estimated as $16/34 \times 4/6 = 0.31$. This is the estimated fraction of elusive AGN among galaxies not classified as Seyfert. Veilleux et al. (1995) estimate that the fraction of optical H II/LINER (i.e. *non*-Seyfert) galaxies in this luminosity range is 85 per cent. Therefore the estimated fraction of elusive AGN in this luminosity range should be $31 \times 0.85 \approx 26$ per cent of all galaxies. However, we have to apply another correction to account for the lack of galaxies with luminosity $< 10^{11.25}$ in the Smith et al. sample. By interpolating with the lower luminosity bin discussed above, we finally estimate that the total fraction of elusive AGN in the luminosity range $10^{11} < L_{\text{IR}}/L_{\odot} < 10^{12}$ is ≈ 20 per cent. We again illustrate this result in Fig. 2 together with the fraction of Seyfert galaxies identified optically by Veilleux et al. (1999), i.e. 2 per cent for Sy1 and 13 per cent for Sy2.

ULIRGs. In this paper we do not discuss ultraluminous infrared galaxies (ULIRGs, $L_{\text{IR}}/L_{\odot} > 10^{12}$), since they are much sparser and

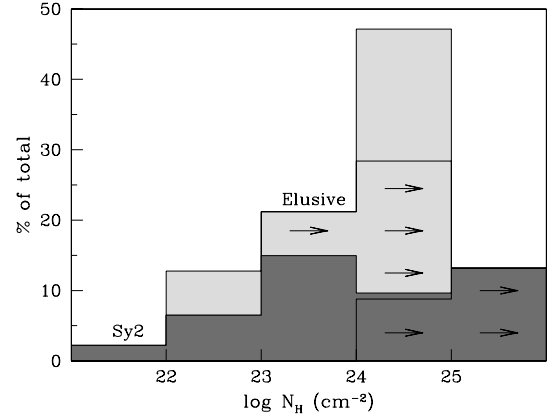


Figure 3. Cumulative distribution of absorbing N_{H} for Sy2 and elusive AGN, under the assumption that elusive AGN's are as numerous as Sy2. The dark-grey histogram shows the contribution by Sy2, while the light-grey histogram shows the contribution by elusive AGN. Histograms marked with arrows show the fraction of objects with a lower limit on N_{H} .

poorly representative of the local population of galaxies. However, for completeness, we also include in Fig. 2 the fraction of elusive AGN among ULIRGs as derived from X-ray observations in the literature (Franceschini et al. 2003; Ptak et al. 2003; Risaliti et al. 2000)⁴ along with the fraction of Seyferts optically identified by Veilleux et al. (1999). Combining these data we obtain: Sy1 = 9 per cent, Sy2 = 21 per cent and elusive AGN = 14 per cent.

We note that the fractions of elusive AGN inferred above are probably lower limits because we have assumed that galaxies not matching the selection criteria of Kewley et al. and Smith et al. do *not* host elusive AGN. The obvious counterexample of NGC 4945 demonstrates that this assumption is a conservative one. Moreover, there are some examples of classical Seyfert nuclei without a detected radio core, and therefore elusive AGN without a radio core may also exist. Finally, a large fraction of the elusive AGN in Table 2 are relatively well-studied objects with better X-ray data (longer integrations and more detailed analysis). Elusive AGN may have been missed in other objects which have received less attention.

5 THE NATURE OF ELUSIVE AGN

It is not clear why elusive AGNs do not produce the typical Seyfert-type emission lines in their optical spectra. Dilution by the circumnuclear region or by the host galaxy may be an explanation; in particular Moran, Filippenko & Chornock (2002) have shown that this may be the case for some of the X-ray-selected AGN at high redshift. However, most of the objects in our sample are very nearby and have been studied in great detail, and generally no optical Seyfert-like signatures were found (but see notes to Table 2). A lack of an ‘UV bump’ typically observed (or inferred) in Seyferts is also unlikely: at least some elusive AGN show strong emission from hot dust (Genzel et al. (1998) for UGC 5101, Krabbe, Böker & Maiolino (2001) for NGC 4945, Maiolino et al., in preparation for NGC 3690) which must be heated by the UV bump associated with the X-ray emission.

The X-ray spectra of elusive AGN provide some hints of their nature. Indeed, most elusive AGN are Compton-thick ($N_{\text{H}} > 10^{24} \text{ cm}^{-2}$). Fig. 3 shows the cumulative N_{H} distribution of elusive AGN

³ Most of the Seyfert in the Maiolino & Rieke (1995) sample fall in this luminosity range. We do not use the fraction obtained by Veilleux et al. (1995) because their AGN statistics in this luminosity range are too poor (two AGN).

⁴ Note that the IR luminosities of the galaxies were adjusted to $H_0 = 75 \text{ km s}^{-1} \text{ Mpc}^{-1}$, the value adopted for this paper.

and Sy2 (the latter from Risaliti, Maiolino & Salvati 1999),⁵ under the assumption that elusive AGN and Sy2 have the same local density. The comparison of the N_{H} distributions indicates that elusive AGN are more absorbed than Sy2. This strongly suggests that the elusive nature of this class of nuclei is associated with heavy obscuration.

One possibility is that the narrow-line region (NLR) is also heavily obscured along our line of sight. However, spectroscopic observations in the near-IR and mid-IR, where dust extinction is much reduced, did not detect the expected narrow emission lines in several of these objects (Marconi et al. 1994; Spoon et al. 2000; Genzel et al. 1998; Maiolino et al., in preparation). Moreover, the NLR is generally too extended to be completely obscured.

Another possibility is that the nuclear pc-scale absorber is not distributed in the torus-like geometry typically assumed for Seyfert 2 nuclei, but covers the nuclear UV source in all directions. In this case, the UV photons cannot escape to produce a classical NLR. Detailed studies of NGC 4945 favour this scenario (Marconi et al. 2000; Moorwood et al. 1996). Indeed, the clouds located in the cavity produced by the nuclear starburst superwind are very faint and only weakly ionized, implying that they are not exposed to the strong photoionizing UV continuum which is expected to be associated with the X-ray emission. As suggested by Done et al. (2003) a disc/torus of Compton-thick material may extend (though with lower N_{H}) to high latitudes and totally cover the AGN. A similar scenario was also proposed by Dudley & Wynn-Williams (1997), who predict that such embedded AGN should be characterized by a deep silicate absorption at $9.7 \mu\text{m}$. Notably, our sample includes some of the objects with the deepest silicate absorption, e.g. NGC 4945 (Maiolino et al. 2000) and NGC4418 (Spoon et al. 2001).

6 CONCLUSIONS AND DISCUSSION

By combining new and past hard X-ray observations we have defined a small sample of optically elusive AGN, i.e. nuclei with optical spectra that do not show any evidence for the presence of a Seyfert nucleus, but with X-ray properties indicative of a heavily obscured AGN (with Seyfert-type luminosity). After accounting for selection effects, we estimate that the fraction of galaxies with elusive AGN may be relatively high, i.e. comparable to or higher than classical, optically classified Seyfert nuclei. As a consequence, the local total density of AGN may be a factor of ~ 2 higher than estimated from optical spectroscopic surveys. Our results also imply that the ratio between obscured and unobscured AGN is higher than estimated previously, i.e. about 7:1 in the luminosity range $\log(L_{\text{IR}}/L_{\odot}) < 11$ and about 16:1 in the luminosity range $11 < \log(L_{\text{IR}}/L_{\odot}) < 12$.

Nearly all elusive AGN are heavily absorbed in the X-rays (Compton-thick), suggesting that their elusive nature is associated with heavy obscuration. The geometry of the obscuring medium may be different than in Sy2 galaxies. In particular, the extension of the Compton-thick medium may completely embed the nuclear source, preventing UV photons from escaping and producing the narrow-line region.

The X-ray spectral properties of elusive AGN may have important implications for the X-ray background. Indeed, while weak at $E < 10 \text{ keV}$ (because of the strong absorption), the X-ray spectral energy distribution of those elusive AGN observed above 10 keV peaks at

about 30 keV, owing to an absorbing column density in the range $10^{24} < N_{\text{H}} < 10^{25} \text{ cm}^{-2}$, and therefore may provide an important contribution to the peak of the X-ray background at 30 keV. Most of these elusive AGN would not be detected below 10 keV in *Chandra* and *XMM* surveys, except in the X-ray brightest-cases. Such sources may be the so-called X-ray bright optically normal galaxies (XBONGs, Comastri et al. 2003). However, an assessment of the contribution of elusive AGN to the 30-keV background bump requires a better knowledge of their luminosity distribution. An *XMM* programme aimed at studying a sample of candidate local elusive AGN, recently approved for AOT3, will help to tackle these issues.

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⁵ We removed NGC4945 and NGC1808 from the sample of Risaliti et al., which were included because of their Seyfert-like X-ray spectra and not because of their optical classification.

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